Sept. 15, 1953

A. C. HOYLE ET AL

2,652,230

WINCH

Filed Feb. 16, 1949

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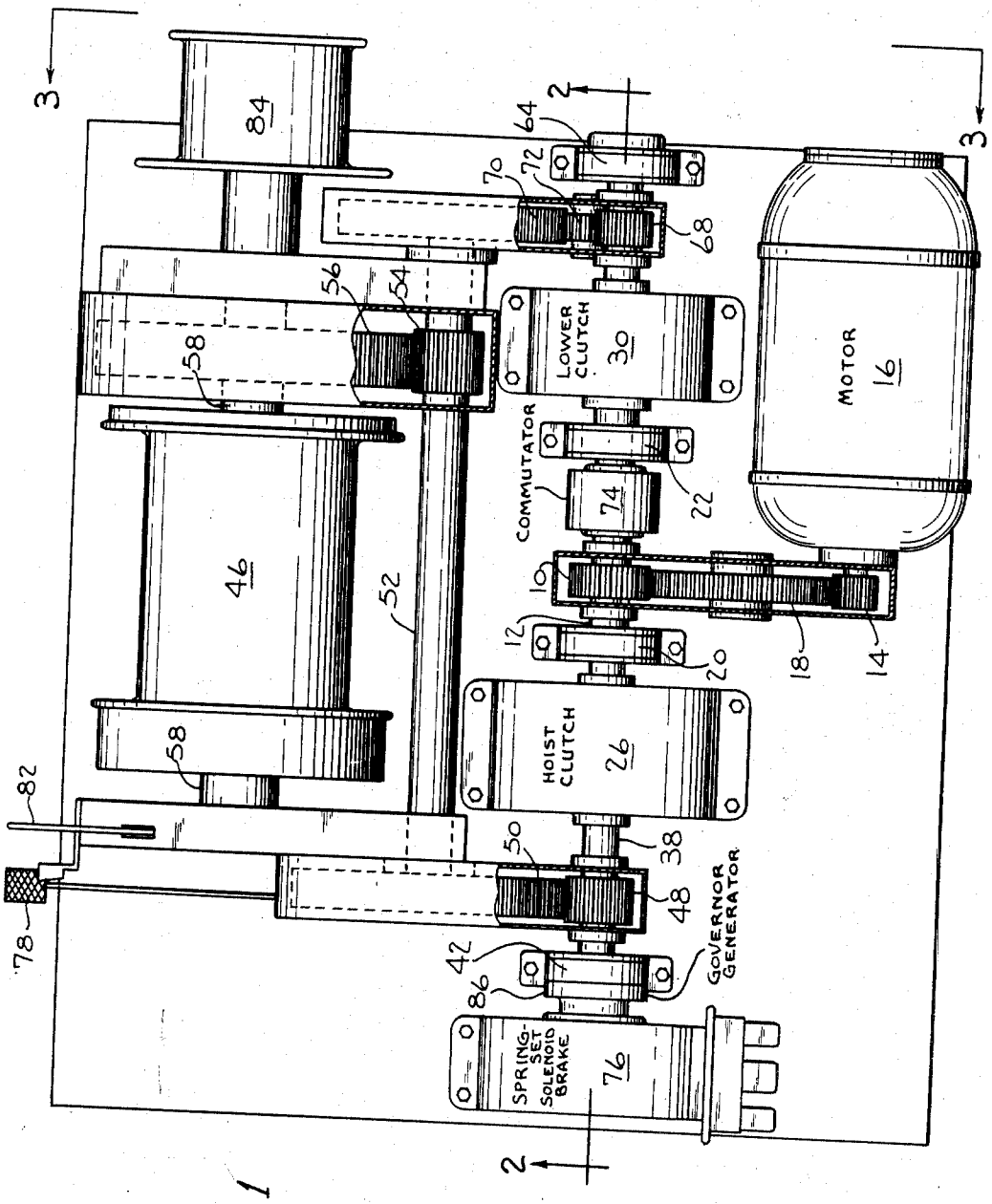

FIG. 1

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4 Sheets-Sheet 2

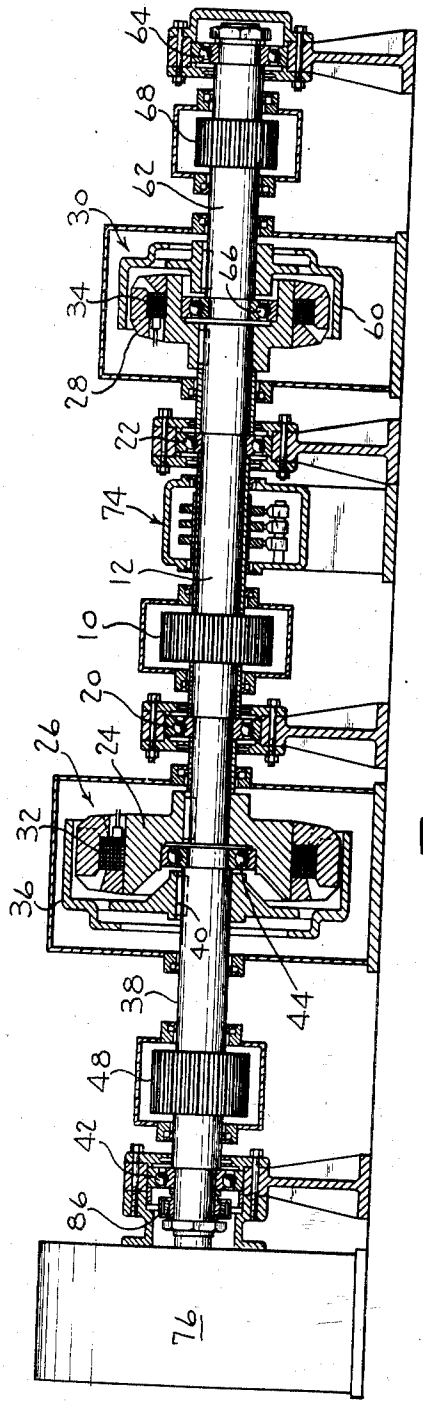

FIG. 2

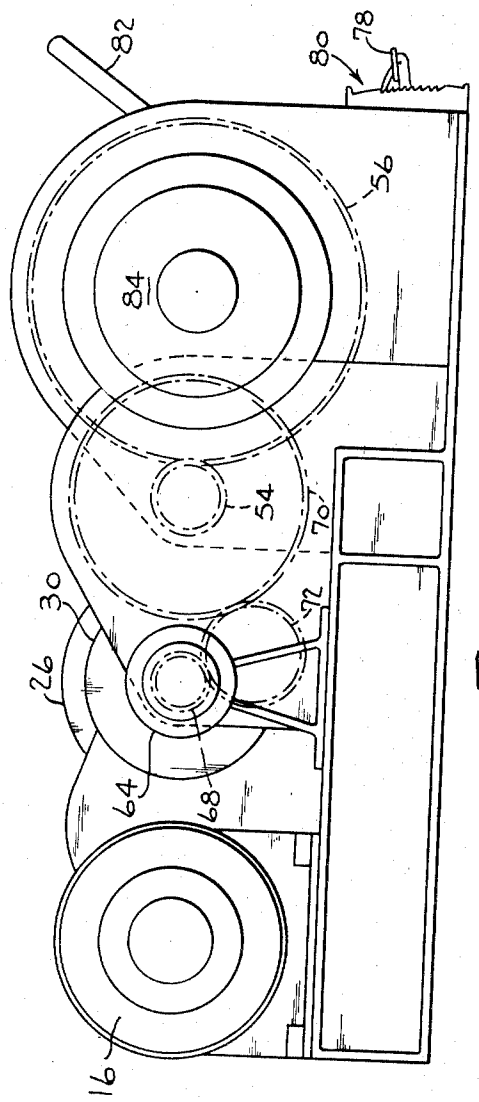

FIG. 3

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Sept. 15, 1953 A. C. HOYLE ET AL 2,652,230

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Filed Feb. 16, 1949 4 Sheets-Sheet 3

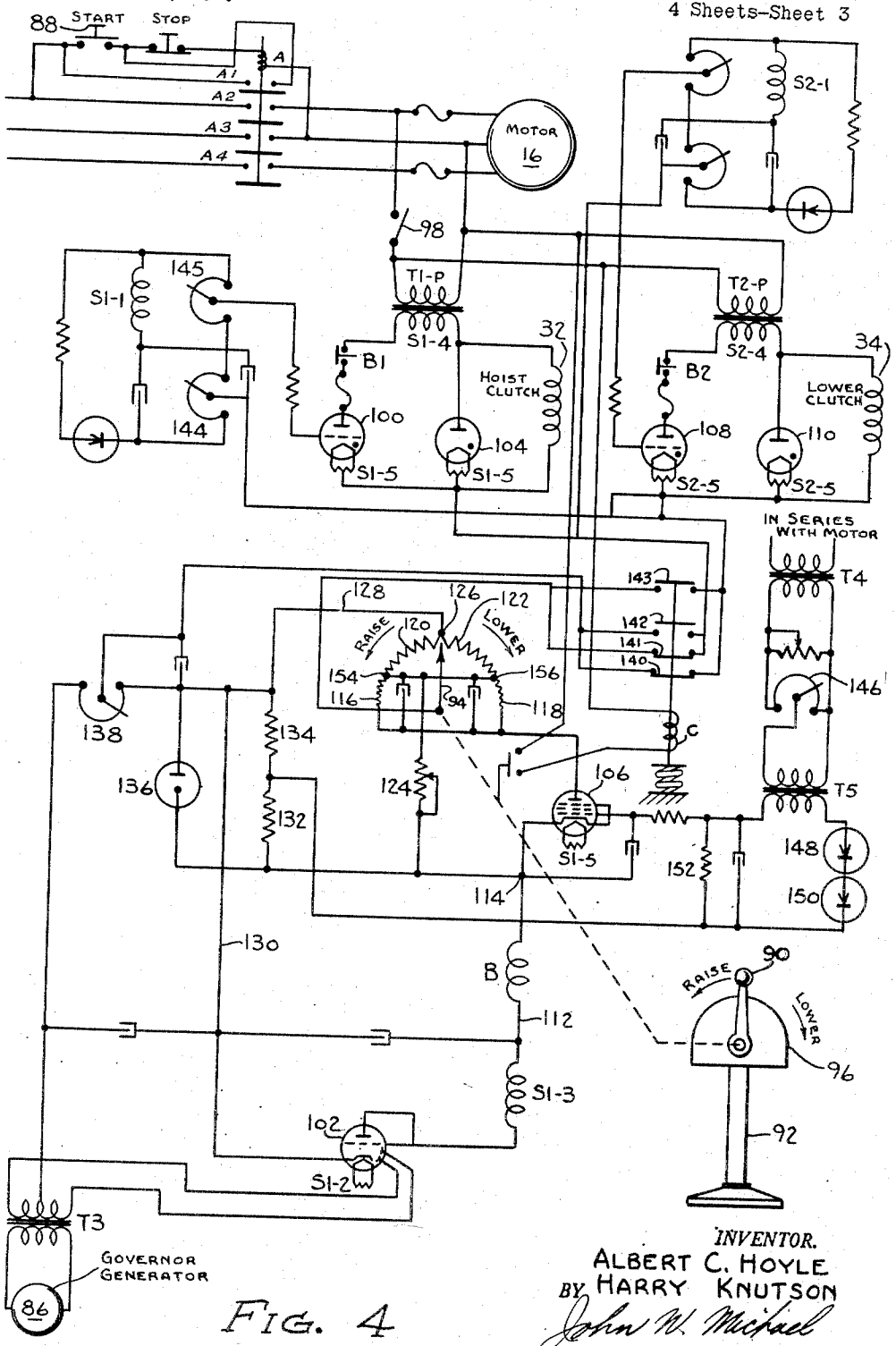

FIG. 4

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4 Sheets-Sheet 4

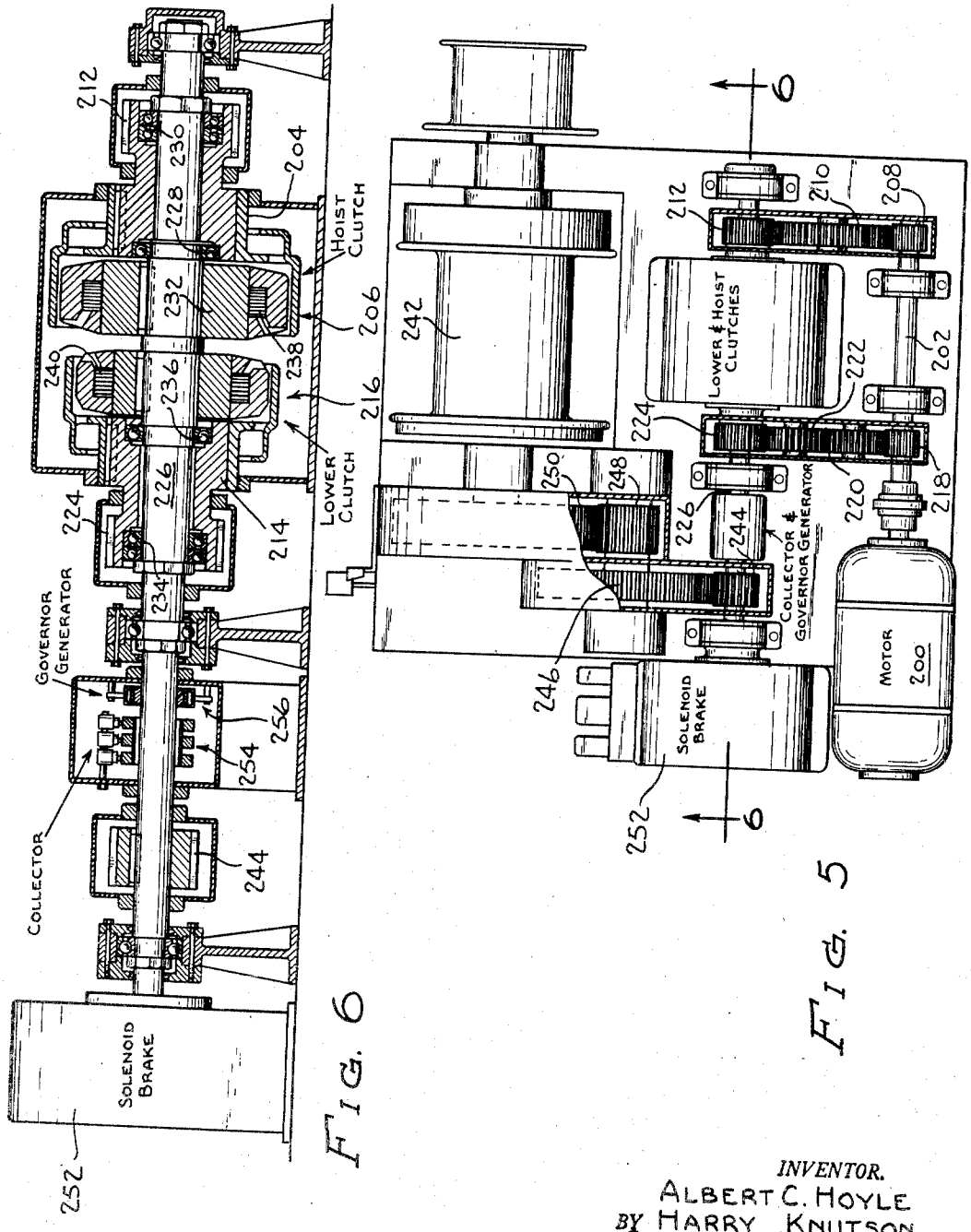

FIG. 6

FIG. 5

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WINCH

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3 Claims. (Cl. 254—173)

1

This invention relates to a winch mechanism electrically operated on alternating current.

The characteristic speed control, smooth acceleration and deceleration, high speed light hook lowering, and dynamic braking during the lowering operation of D. C. winches have heretofore offset the disadvantages of D. C. operation in many installations where it would be highly desirable to utilize A. C. Modern ships, for example, utilize A. C. for all machinery except the cargo winches since known A. C. winches having a squirrel cage or a slip ring motor directly geared in the winch mechanism proved unsatisfactory. Since, on cargo vessels, the total winch power required about equals the total power in use at sea, it is evident that the use of A. C. exclusively is highly desirable and advantageous.

The principal object of this invention is to provide a reliable alternating current winch which affords desirable operating characteristics.

Another object is to provide an A. C. winch which costs and weighs less than a comparable D. C. winch.

A further object is to provide an A. C. winch which may utilize a simple squirrel cage motor while obtaining desirable operating characteristics.

A further object is to provide an A. C. winch which holds its adjusted speed independent of the load up to rated load.

Another object is to provide an A. C. winch which affords dynamic braking during lowering operations while having a fast light line speed.

A further object is to provide a winch structure in which the motor runs constantly, thus limiting the load starting ability by the motor pull-out torque rather than its starting torque.

Still a further object is to provide an A. C. winch which is faster in operation than a comparable D. C. winch.

Other objects and advantages will be pointed out in, or be apparent from, the specification and claims, as will obvious modifications of the embodiments shown in the drawings, in which:

Fig. 1 is a plan view of a winch with some casing parts broken away;

Fig. 2 is a vertical section of the drive shaft as indicated by line 2—2 in Fig. 1;

Fig. 3 is an end elevation of Fig. 1 taken from line 3—3;

Fig. 4 is a circuit diagram of the control mechanism for the winch;

Fig. 5 is a plan view of a modified form of the winch with some casing parts broken away; and

2

Fig. 6 is a vertical section taken on line 6—6 of Fig. 5.

Referring now to Figs. 1 and 2 in detail, gear 10 mounted on shaft 12 is driven by gear 14 on the drive shaft of the A. C. motor 16 through idler gear 18 to turn shaft 12 in its bearings 20, 22. The driving element 24 of hoist clutch 26 is keyed on the left hand end of shaft 12, while the driving member 28 of lower clutch 30 is keyed on the right-hand end of shaft 12. The driving members 24, 28 are respectively provided with coils 32, 34 which may be energized to create a magnetic field having a flux density depending upon the degree of energization or excitation of the coils. Thus poles 36 on the output of raise clutch 26 are rotated at a speed dependent upon the flux density set up by coils 32 (the speed of rotation of motor 16 being taken as constant) to drive shaft 38 to which the poles are keyed at 40. The shaft 38 is journaled adjacent its left-hand end in bearing 42 and at its right-hand end in bearing 44 which additionally serves to center the driven member 36 of raise clutch 26. Rotation of shaft 38 is transmitted to the winch drum 46 by means of pinion gear 48 mounted on shaft 38 and driving gear 50 on the left-hand end of countershaft 52 which has a pinion 54 mounted adjacent its right-hand end and turning gear 56 mounted on drum shaft 58.

Thus the rotational speed of drum 46 in the hoisting direction may be varied by regulating the flux density in the raise clutch 26 to vary the degree of slip between the constant speed shaft 12 and shaft 38 on the output side of the electro-magnetic clutch 26. The rotational speed of drum 46 in the lowering direction may be similarly controlled by regulating the flux density in coil 34 on the lower clutch 30 to act on poles 60 keyed to shaft 62. The shaft 62 is journaled at 64, 66 in the manner similar to shaft 38 and has a pinion gear 68 which drives gear 70 on countershaft 52 through reversing gear 72. Thus the drum 46 is driven in the lowering direction when clutch 30 is energized.

The current is fed into suitable wiring, not shown, on shaft 12 to the coils 32, 34 of clutches 26 and 30 through collector 74. The current supply is regulated by means to be described hereinafter. Obviously if neither clutch were energized, the drum 46 would be free to rotate, and for this reason the left-hand end of shaft 38 which is geared to drum 46 is provided with a conventional spring-set solenoid released brake 76. Thus when current is passed to either clutch, current is also passed to the operating solenoids

on the brake 76 to release the brake and permit the winch mechanism to rotate. However, when current is interrupted, either intentionally or due to power failure, the coils of the operating solenoids on the brake 76 are no longer energized and the springs set the brake shoes.

The winch structure may be augmented by the provision of a band type brake operated by a foot lever 78 equipped with a latching mechanism 80 to hold the brake in set position. Another safety feature may be in the form of a ratchet and pawl assembly, not shown, operated by lever 82. To provide for further utility, a gypsy head 84 may be keyed to the right-hand side of shaft 58 and, if desired, a clutch, not shown, may be provided to allow independent use of the gypsy head. In order to adapt this winch structure to shipboard use, various casings may be provided, as indicated in Figs. 1 and 2 and in side elevation in Fig. 3, to render the entire assembly watertight.

This type of assembly provides highly desirable operating characteristics while utilizing alternating current. Considering the first operation of the winch with no load applied to drum 46, it will be evident that hoist clutch 26 is energized to provide for drum rotation in the hoist direction. The degree of slip between input and output of clutch 26 bears an inverse relationship with the degree of energization or the flux density in coils 32 in the hoist clutch. It follows, therefore, that the speed of rotation of drum 46 will bear a direct relationship to the degree of energization of the coils. In a similar manner the speed of rotation of the drum in the reverse direction will bear a direct relationship to the degree of energization of coil 34 on the lower clutch 30 with no load on the drum.

It will now be evident that a heavy load on the cable wrapped on drum 46 will tend to strip cable from the drum and rotate the drum at a speed greater than that determined by the energization of coil 34 in the lower clutch 30, thus tending to overrun the drive. It is obvious, therefore, that it is necessary to provide some means for retarding or checking the speed of drum rotation under such conditions. The output of governor generator 86 mounted on shaft 38 is utilized to provide for control over this type of situation and will cause the lower clutch 30 to be deenergized and the hoist clutch 26 to be energized by means to be described hereinafter to cause the hoist clutch to act as a dynamic brake when lowering heavy loads. The output voltage of governor generator 86 is also utilized in regulating the energization of either clutch to maintain a preselected speed of drum rotation. Other aspects of the control system for these clutches will become apparent in the following description.

The electrical circuit (Fig. 4) is utilized in operation of motor 16 and in controlling the energization of coils 32, 34 in the hoist and lower clutches. To start motor 16 the starting button 88 is depressed to energize coil A which closes relays A1, A2, A3 and A4 to close the circuit to the motor. The remainder of the controls are electronic and are manually regulated by movement of handle 90 mounted on a suitable pedestal 92 on the ship's deck to move the wiper 94 over a potentiometer, movement of the lever in one direction past the top or neutral position being operable to energize the winch mechanism in the hoist direction and to energize the winch in the lowering direction when moved past the neutral position in the opposite direction. The electronic components of the controls are conveniently housed within casing 96 on pedestal 92 and are placed into operation by closing switch 98 to energize the primary coils T1–P and T2–P of two transformers.

Assuming first that wiper 94 is in the neutral position, energization of coil T1–P sets up current flow in the secondaries (all bearing the identifying legend S1) to this transformer. Thus S1–1 is utilized in a grid circuit to impose a rectified bias on the grid of gas tube 100. S1–2 heats the cathode of tube 102. S1–3 sets up a plate voltage in tube 102 causing this tube to fire and set up a current flow through four parallel circuits to be described hereinafter. S1–4 sets up current flow in the hoist clutch coil circuit, and S1–5 heats the cathodes in tubes 100, 104 and 106.

Closure of on-off switch 98 also sets up current flow in the primary T2–P of another transformer having a plurality of secondaries. The secondary winding S2–1 sets up the desired grid bias on gas tube 108 in the lower clutch coil circuit. Secondary winding S2–4 sets up a current flow in the lower clutch coil circuit, and S2–5 heats the cathodes in tubes 108, 110.

Referring now to the four parallel circuits, mentioned above, supplied by current flow through tube 102 by virtue of the initial heating of its cathode and the plate voltage supplied when the on-off switch 98 is closed. Current flow through line 112 energizes coil B to close relays B1, B–2 in the hoist and lower clutch coil circuits, respectively. The current flow through line 112 branches at junction 114 into the four parallel circuits. The first circuit is through tube 106 to set up a potential on resistances 116, 118 in the potentiometer. The ptoential set up on these resistances may for the time being be disregarded, and the slight potential set up on resistors 120, 122 of the potentiometer by virtue of current flow through tube 106 may also be neglected since resistances 120, 122 are appreciably less than resistances 116, 118 and the voltage thereacross is therefore negligible. The second of the four parallel circuits sets up current flow through variable resistor 124 and imposes a reference potential on resistances 120, 122 of the potentiometer with the return to tube 102 being off the central tap 126 through lines 128, 130. The third of the four parallel circuits flows through resistors 132, 134 and back to tube 102 through line 130. The fourth and last of the parallel circuits sets up current flow through voltage regulator 136 back to tube 102 through line 130 and maintains constant voltage in each branch of the parallel circuit just described.

Under these conditions with the wiper 94 in the neutral point or at junction 126 on the potentiometer, it will be seen that there is no current flow through either of clutch coils 32, 34 since the bias on the grids of tubes 100, 108 in the hoist and lower circuits, respectively, is preselected to merely provide a reference point and not to provide the bias necessary to cause the tubes to fire. When wiper 94 is moved into the raise portion of the potentiometer or onto resistance 120, a positive potential is placed on the grid of tube 100 by means of current flow through the variable resistor 138, normally closed relay 140, and the adjustment resistors 144, 145. Similarly, it will be noted that a positive potential is simultaneously placed on the cathode of the lower clutch control tube 108, thus blanking out this circuit while the positive potential on tube

100 causes current flow through coil 32 to energize the hoist clutch. As the speed of drum rotation increases, the voltage output of governor generator 86 is fed into the circuit through transformer T3 and is rectified in tube 102. The output of the governor generator is imposed across the variable resistance 138 in series opposition to the voltage selected by means of the potentiometer. Thus the increasing speed of the drum and, consequently, of the governor generator will now reduce the positive bias on the grid of tube 100 to reduce the current flow through coil 32 in the hoist clutch until a servo-balance is obtained. When the output of the governor generator is balanced with the selected voltage, the bias on the grid of tube 100 causes a steady flow of current through coil 32 to maintain a constant selected speed of drum rotation.

When the wiper 94 is moved to the lower portion of the potentiometer or onto resistance 122, a coil C is energized to open normally closed relays 140, 141 and to close the normally open relays 142, 143. Assuming for the moment there is no load on the drum and the winch is operating under light line conditions, it will be apparent that the switching accomplished by means of relays 140, 141, 142 and 143 will now impose a positive bias on the cathode of the hoist tube 100 to blank out the tube while restoring the negative bias to the cathode of tube 108 and placing a positive bias on its grid to cause this tube to fire and energize the lower clutch coil 34. As the drum rotation in the lowering direction increases, it will be apparent that the governor generator output in series opposition across resistance 138 will decrease the positive bias on the grid of tube 108 until equilibrium is reached. Under these conditions the cable on drum 46 is driven down by means of the lower clutch.

If, however, the drum is loaded to such an extent that the output side of lower clutch 30 tends to overrun the speed selected by means of the potentiometer setting the voltage output of the governor generator becomes greater than the voltage selected by means of the potentiometer thus reducing the bias on the grid of tube 108 to the point where the tube becomes blanked out. However, since the control tubes 100 and 108 in the two clutch circuits are so interconnected that the grid of one is in circuit with the cathode of the other and vice versa, such blanking out of tube 108 due to the drum overrunning the selected speed will simultaneously result in a positive bias being imposed on the grid of the hoist control tube 100. Similarly the cathode of tube 100 which has up to this time been positive now becomes negative, and the tube fires, causing the hoist clutch to be energized. When the hoist clutch is thus energized it acts as a dynamic brake on the winch mechanism. Therefore, while the load continues to lower, the hoist clutch is energized to such an extent that the lowering speed is maintained at the selected value.

Thus it will be apparent that the electronic controls may be designed to provide for a linear change of speed with movement of wiper 94 across resistors 120 and 122. This circuit also incorporates a torque sensing system which may be utilized to permit loads less than rated load to continue this linear relationship at speeds above that selected as the maximum desirable speed for rated loads. For example, one such installation provides for a maximum line speed in either direction of 220 feet per minute when

handling rated loads but provides for speeds inversely proportional to load between 220 feet and 400 feet per minute.

This torque sensing system is operated from transformer T4 connected in series with the drive motor 16. The output of the transformer T4 is placed across an adjustable resistance 146, stepped up by transformer T5, and then rectified through selenium rectifiers 148, 150. The D. C. output thus obtained is placed across resistance 152. As the load on the drum is increased, the load on motor 16 is similarly increased thus demanding more current which is shown across resistance 152 and results in increasing the negative bias on the grid of tube 106. Thus current flow through tube 106 is reduced as the torque is increased. The circuit is designed as to stop current flow through tube 106 when rated load is handled. When it is remembered that current flow through tube 106 supplies a potential on resistances 116, 118 in the potentiometer in additive relationship to resistances 120, 122 it will be appreciated that stopping current flow through tube 106 will prevent any further increase in voltage as wiper 94 is moved past either junction 154 or 156 on the potentiometer. However, at light line conditions the current flow through tube 106 is unimpeded and movement of wiper 94 past junctions 154, 156 will put an additional potential across resistance 138. Intermediate loads (intermediate torques) will vary the potential imposed on resistances 116, 118 to cause the speeds above the desired maximum for rated loads to be inversely proportional to the load. Referring back to the example above, the junctions 154, 156 may represent a speed of 220 feet per minute while movement of wiper 94 past either of these junctions with a load less than rated load will result in speeds above 220 feet per minute up to a maximum of 400 feet per minute.

The wiring diagram and principle of operation described above are equally applicable to the modified winch shown in Figs. 5 and 6 where motor 200 is coupled to and drives the shaft 202 to turn the driving element 204 of hoist clutch 206 through a gear train including gears 208, 210 and 212. Motor 200 turns driving element 214 of lower clutch 216 in the opposite direction through another gear train including gears 218, 220, 222 and 224. Driving element 204 of hoist clutch 206 is rotatably mounted on shaft 226 by means of bearings 228 and 230 while the driven element 232 of the hoist clutch is keyed to the shaft. Driving element 214 of lower clutch 216 is similarly rotatably mounted on shaft 226 by bearings 234, 236, and the driven member of the lower clutch is keyed to shaft 226.

Thus when coils 238, 240 in the driven members of hoist and lower clutches 206, 216, respectively, are not energized, driving elements 204, 214 of the clutches are turned in opposite directions about shaft 226 by motor 200. Should coils 238 in driven part 232 of hoist clutch 206 be energized, the driven part of the clutch will rotate at a speed dependent upon the flux density to turn shaft 226 and drive drum 242 in the hoisting direction through a gear train including gears 244, 246, 248, and 250. Conversely, if coils 240 in lower clutch 216 were energized, shaft 225 would be driven in the opposite direction to turn drum 242 in the lowering direction through the gear train.

The winch assembly is completed by provision of solenoid brake 252, collector rings 254, and

governor generator 256. It will be readily apparent that the output of governor generator 256 may be fed into the electrical circuit described above to obtain the proper regulated current to be fed into coils 238, 240 through collector rings 254. This arrangement has some advantages over the modification shown in Figs. 1 through 3 in that the shaft lengths and bearing pressures may be materially reduced. Furthermore this modification may be made more compact than the other.

It will be apparent, therefore, that I have provided a winch mechanism operating on alternating current which has all the desirable operating characteristics of direct current winches while having less weight and lower cost than direct current winches. It will be noticed that the alternating current motor 16 runs continuously as compared to D. C. winches which are stopped whenever the load is stopped. This winch, then, is limited not by its starting torque as is a D. C. winch, but by its pull-out torque. For this reason this alternating current winch can handle bigger loads. Another advantage in having a continuously operating motor resides in obtaining faster operation of the winch since only slow speed parts are accelerated in the present winch while a D. C. motor must accelerate heavy parts to high speeds. The electrical circuit described above may be so adjusted by means of the variable resistors located in the grid circuits of the control tubes of each clutch to provide extremely safe landing speeds wherein a rated load may be lowered at a virtual creep.

This invention is not concerned with the details of this specific control circuit but is concerned with the electrical circuit only insofar as providing for power hoisting and lowering and for dynamic braking when lowering heavy loads. Thus the invention resides in providing a winch structure having two clutches, one for hoisting and one for lowering with the hoisting clutch serving as a dynamic brake when lowering overrunning loads. It is believed to be apparent that there are other circuits which may be designed to provide these operating characteristics and that the design of such a circuit is in the province of an experienced electronic control designer.

Obvious changes in the arrangement of the clutches and in the drive from the clutches to the drum will occur to those skilled in the art. For example, one of the experimental embodiments in the development of the present winch utilized clutches arranged to drive through a planetary transmission, but was thought to be unsatisfactory due to the necessary high planetary gear speed. Therefore, this invention is to be limited only by the scope of the claims.

We claim:

1. A winch comprising, in combination, a motor, first and second clutches having input and output members, the input members being driven by said motor, a drum, the output member of the first clutch being connected to said drum to rotate the drum in the hoisting direction, the output member of the second clutch being connected to said drum to rotate the drum in the lowering direction, each clutch including controllable means for transmitting force between the input and output members at a variable slip between the members, means for regulating said controllable means in the first clutch to drive the drum at a selected speed in the hoisting direction, means for regulating said controllable means in the second clutch to drive the drum at a selected speed in the lowering direction, and means responsive to a lowering speed greater than the selected lowering speed due to an overrunning load on the drum to regulate said controllable means in the first clutch so the first clutch acts as a brake and maintains the selected lowering speed.

2. In a winch, a motor, a first electromagnetic clutch driven by said motor and being connected to a drum to turn the drum in the hoisting direction, a second electromagnetic clutch driven by said motor and being connected to said drum to drive the drum in the lowering direction, means for energizing the first clutch to vary the flux density and regulate the hoisting speed of the drum, means for energizing the second clutch to vary the flux density and regulate the lowering speed of the drum, and means responsive to a lowering speed greater than a preselected lowering speed to de-energize the second clutch and to energize the first clutch to act as a brake and prevent overrunning.

3. A winch having in combination, a motor, a cable drum, a pair of clutches for connecting said motor to said drum, the first of said clutches being operative to transmit a force to said drum tending to rotate the drum in the hoisting direction, the other of said clutches being operative to drive the drum in the lowering direction, said clutches being of the electromagnetic type wherein the flux density is varied to vary the force transmitted thereby, means for selecting a hoisting speed and for controlling the flux density in the first clutch to maintain the selected speed, means for selecting a lowering speed and for controlling the flux density in said other clutch to drive the drum in the lowering direction when its speed is at or below the selected speed, and means responsive to a lowering speed in excess of the selected lowering speed to deenergize said other clutch and to energize said first clutch to dynamically brake the drum.

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